Conventional Foundations	
Slab-on-Grade	$4.61 per sq. ft.
Crawl Space	$5.13 per sq. ft.
Basement	$11.01 per sq. ft.
Elevated Foundations	
Wood Post	$6.96 per sq. ft.
Wood Pile	$6.58 per sq. ft.
Concrete Pier	$7.08 per sq. ft.

Estimates—Spring 1983

Figure 5.3. Foundation Cost Estimates

2. The estimates are summarized in Figure 5.3. They are based on the foundation and deck of a 1,500-square-foot house, 28'x50', with a small offset. The total cost of this house is approximately $60,000, excluding land. All estimates were based on FHA construction practices.

3. Using data from this cost sampling, the average cost of each conventional foundation type is compared to the average cost of each elevated foundation type. This comparison is done in two ways: first, each foundation as a percentage of the cost of the *entire* house (conventional foundations were established as base 100) and, second the dollar increase in the cost of the foundation above.

	Elevated Foundations	**Conventional Foundations**		
		Slab on Grade	Crawl Spaces	Basement
% Increase of Total House Cost	Wood Post	+5.9	+4.6	−10.1
	Wood Pile,	+4.9	+3.6	−11.1
	Concrete Pier	+6.2	+4.9	−9.8
Dollar Increase, Foundation Cost Only	Wood Post	$3,525	$2,745	−$6,075
	Wood Pile	$2,955	$2,175	−$6,645
	Concrete Pier	$3,707	$2,925	−$5,895

Figure 5.4 Cost Differentials, Conventional Vs. Elevated Foundations, for House Costing $60,000, Excluding Land.

4. Figure 5.5 graphically compares the cost of constructing the different types of foundations at various elevations. Note that increasing the elevation increases costs at a substantial rate only in the case of the fill option (which is based on the availability of usable fill material on the site).

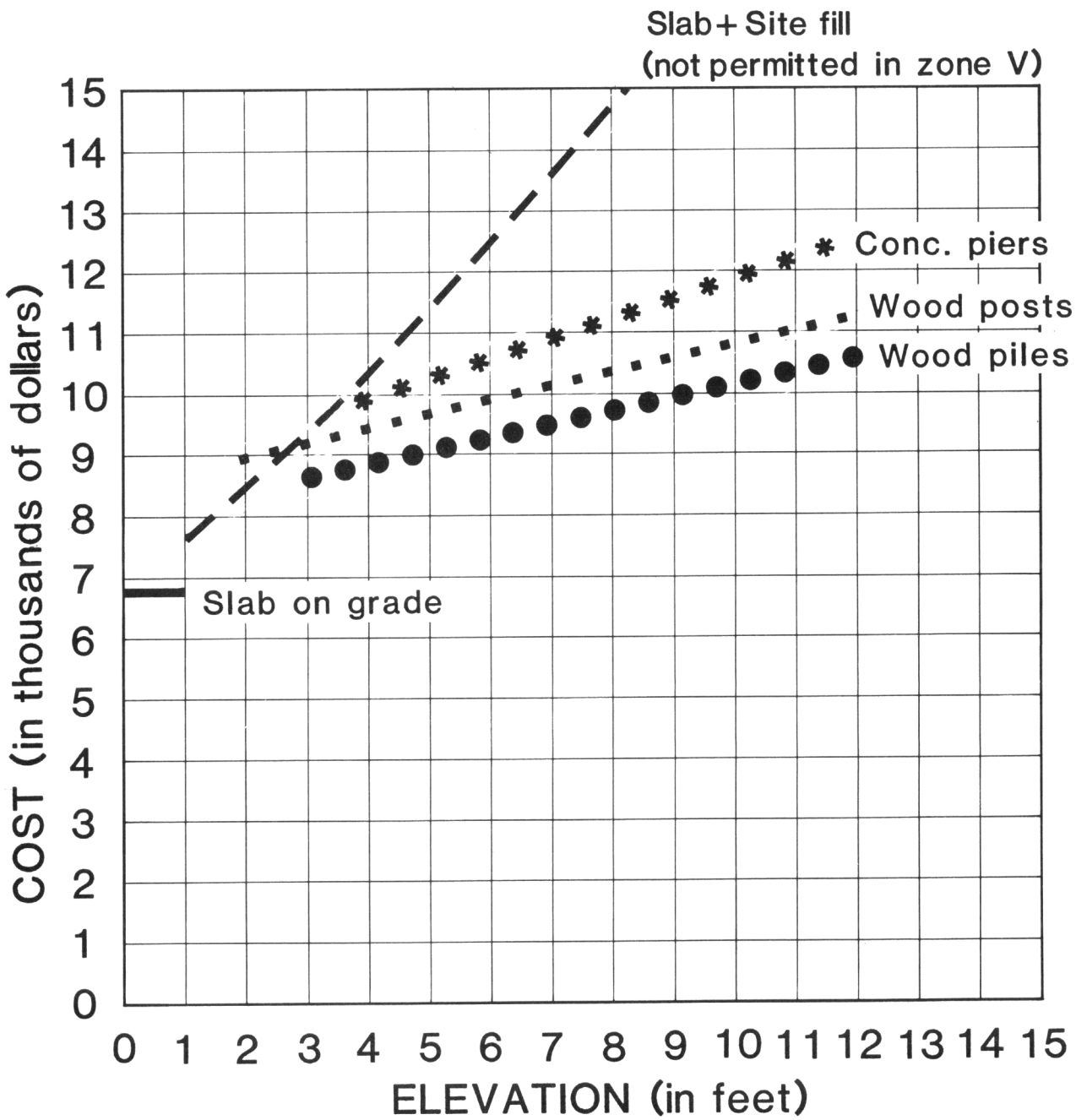


Figure 5.5. Relative Costs of Foundations Elevated to Different Heights

Fill

Fill can often be used in A Zones to elevate conventional foundations such as slab-on-grade. The cost of this approach varies widely, depending on the availbility, quality, and unit cost of fill as well as the height and compaction necessary. Local building officials or soils engineers should be consulted to evaluate local conditions.

COST COMPARISON CAVEATS

The comparative cost data given above do not take into account a number of factors that can affect either basic construction costs or long-term insurance costs.

Insurance Costs

Insurance rates under the NFIP vary greatly depending on the elevation of a building and other features related to flood safety. Differences in these rates can overshadow the construction cost differentials discussed in this chapter, and should be considered carefully in making design decisions.

Design Assumptions

Each house elevated on piles, posts, and piers was assumed to have 21 foundation elements. In addition, each element was assumed to be an average length that included the length below grade and the length between grade and the structure. These lengths are 16 feet for piles, 14 feet for posts, and 15 feet for piers. In practice, both the number and length of foundation elements will vary depending on soil conditions, expected flood levels, etc.

Earthquakes

Constructing elevated foundations in earthquake areas may require additional structural expenditures that should be noted in cost estimates. Local building officials or a structural engineer should be consulted to evaluate local conditions.

Stairs and Utilities

Elevating a residence may result in increased cost for stairs and for utilities that must be elevated above grade. These costs were not considered in the estimates presented here since they vary with height of elevation, cost assignment, i.e., who pays for installation of utilities, and elevation method.

Regional Cost Variations

The cost data presented above are based on national averages, and do not take into account regional cost variations.

Cost Inflation

Building costs are difficult to predict because of the tendency for the cost of basic construction commodities–lumber, concrete, and steel–to fluctuate and to vary relative to each other. The costs here are estimated using data for the spring of 1983.

Non-Cost Considerations

Cost is not the only determinant for selecting the material and method for elevating. Market acceptance (buyers and banks), architectural design integration, climatic conditions, site conditions, and anticipated flood hazards should also be considered.

ESTIMATING FORMS

The forms on the following pages can be used for making cost estimates for conventional and elevated foundations.

SLAB-ON-GRADE

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

_____ *Square Footage of Floor Area*
_____ *Lineal Footage of Perimeter*
_____ *Square Footage of Foundation Wall*

Enter you costs (combine labor and material) and extend:

Layout house on lot				= $ _____
Trench for footing	_____	x _____	*LF*	= $ _____
Place footings	_____	x _____	*LF*	= $ _____
Lay-up or form & pour foundation wall	_____	x _____	*SF*	= $ _____
Fill & grade for slab	_____	x _____	*SF*	= $ _____
Place vapor barrier, wire mesh & insulation	_____	x _____	*SF*	= $ _____
Place & finish slab	_____	x _____	*SF*	= $ _____
		Grand Total		$ _____

CRAWL SPACE

ESTIMATING FORM TO DETERMINE LOCAL COSTS

Compute the following and enter:

_____ *Square Footage of Floor Area*
_____ *Lineal Footage of Perimeter*
_____ *Square Footage of Foundation Wall*
_____ *Number of Piers*

Enter your costs (combine labor and material) and extend:

Layout house on lot				= $ _____
Trench for footing	_____	x _____	*LF*	= $ _____
Place footings	_____	x _____	*LF*	= $ _____
Lay-up or form and pour foundation wall	_____	x _____	*SF*	= $ _____
Place pier footings	_____	x _____	*Ea.*	= $ _____
Lay-up or form and pour piers	_____	x _____	*Ea.*	= $ _____
Backfill	_____	x _____	*CY*	= $ _____
Floor Girder	_____	x _____	*LF*	= $ _____
Floor Framing	_____	x _____	*SF*	= $ _____
Insulation & sealer	_____	x _____	*SF*	= $ _____
Subfloor	_____	x _____	*SF*	= $ _____
Place floor slab	_____	x _____	*SF*	= $ _____

Grand Total $ _____

BASEMENT | **ESTIMATING FORM TO DETERMINE LOCAL COSTS**

Compute the following and enter:

_____ *Square Footage of Floor Area*
_____ *Lineal Footage of Perimeter*
_____ *Square Footage of Basement Wall Area*
_____ *Number of Basement Support Columns*

Enter your costs (combine labor and materials) and extend:

Layout house on lot				= $ _____
Excavation & spoil removal	_____	x _____	*SF*	= $ _____
Place footings	_____	x _____	*LF*	= $ _____
Place pier footings	_____	x _____	*Ea.*	= $ _____
Lay-up or form & pour foundation wall	_____	x _____	*SF*	= $ _____
Parge wall	_____	x _____	*SF*	= $ _____
Set drain tile	_____	x _____	*LF*	= $ _____
Backfill	_____	x _____	*CY*	= $ _____
Place vapor barrier and wire mesh	_____	x _____	*SF*	= $ _____
Place and finish floor slab	_____	x _____	*SF*	= $ _____
Place girder	_____	x _____	*LF*	= $ _____
Frame Floor	_____	x _____	*SF*	= $ _____
Place subfloor	_____	x _____	*SF*	= S _____
		Grand Total		$ _____

WOOD POST

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

_____ *Square Footage of Floor Area*
_____ *Lineal Footage of Girders*
_____ *Number of Posts*

Enter your costs (combine labor and material) and extend:

Layout house on lot		= $ _____
Auger or dig post holes and remove spoil	_____ x ____ *Qty*	= $ _____
Place concrete punching pad	_____ x ____ *Qty*	= $ _____
Place poles	_____ x ____ *Qty*	= $ _____
Backfill poles and plumb	_____ x ____ *Qty*	= $ _____
Set girder	_____ x ____ *LF*	= $ _____
Frame floor	_____ x ____ *SF*	= $ _____
Place insulation & sealer	_____ x ____ *SF*	= $ _____
Place subfloor	_____ x ____ *SF*	= $ _____
	Grand Total	$ _____

WOOD PILE

ESTIMATING FORM
TO DETERMINE LOCAL COSTS

Compute the following and enter:

_____ *Square Footage of Floor Area*
_____ *Lineal Footage of Girders*
_____ *Number of Piles*
_____ *Total Lineal Footage of Piles*

Enter your costs (combine labor and material) and extend:

Layout house on lot				= $ _____
Bring pile-driving equipment to site	_____	x		= $ _____
Furnish and drive piles	_____	x	_____ LF	= $ _____
Set girder	_____	x	_____ LF	= $ _____
Frame floor	_____	x	_____ SF	= $ _____
Place insulation and sealer	_____	x	_____ SF	= $ _____
Place subfloor	_____	x	_____ SF	= $ _____

Grand Total $ _____

CONCRETE PIER | **ESTIMATING FORM TO DETERMINE LOCAL COSTS**

Compute the following and enter:

_____ *Square Footage of Floor Area*
_____ *Lineal Footage of Girder*
_____ *Number of Piers*

Enter you costs (combine labor and material) and extend:

Layout house on lot			= $ _____
Auger or dig pier holes and remove spoil	_____ x	_____ Qty	= $ _____
Place concrete footing	_____ x	_____ Qty	= $ _____
Form & pour piers	_____ x	_____ Qty	= $ _____
Backfill	_____ x	_____ Qty	= $ _____
Set girder	_____ x	_____ LF	= $ _____
Frame floor	_____ x	_____ SF	= $ _____
Place insulation and sealer	_____ x	_____ SF	= $ _____
Place subfloor	_____ x	_____ SF	= $ _____
	Grand Total		$ _____

RESOURCE MATERIALS

Glossary

Base Flood Elevation (BFE)

The elevation for which there is a one-percent chance in any given year that flood levels will equal or exceed it (see *Special Flood Hazard Areas*). The BFE is determined by statistical analysis of stream-flow records for the watershed and rainfall and runoff characteristics in the general region of the watershed.

Coastal High Hazard Area

The portion of a coastal floodplain that is subject to high velocity waters caused by tropical storms, hurricanes, northeasters, or tsunamis. Labeled V Zones on Flood Insurance Rate Maps, these areas experience breaking waves of three feet or more.

Debris Impact Loads

Loads induced on a structure by solid objects carried by flood water. Debris can include trees, lumber, displaced sections of structures, tanks, runaway boats, and chunks of ice. Debris impact loads are difficult to predict accurately, yet reasonable allowances must be made for them in the design of potentially affected structures.

Encroachment

Any physical object placed in a floodplain that hinders the passage of water or otherwise affects flood flows.

Existing Construction

Those structures already existing or on which construction or substantial improvement was started prior to the effective date of a community's floodplain management regulations.

Flood or Flooding

A general and temporary condition of partial or complete inundation of normally dry land areas. Flooding results from the overflow of inland or tidal waters or the unusual and rapid accumulation of surface water runoff from any source.

Flood Insurance Rate Map (FIRM)

An official map of a community, issued or approved by the Federal Emergency Management Agency, that delineates both the special hazard areas and the risk premium zones applicable to the community. Zones are as follows:

Zone A (unnumbered) - special flood hazard area inundated by the 100-year flood; determined by approximate methods with no base flood elevation shown.

Zones A1—A30 - special flood hazard area inundated by the 100-year flood; determined by detailed methods with base flood elevations shown.

Zone B - area between the limits of the 100-year flood and the 500-year flood, or certain areas subject to 100-year flooding with average depths less than 1 foot, or areas protected by levees from the base flood.

Zone C - area of minimal flooding; located outside the limits of the 500-year flood.

Zone V (unnumbered) - area subject to wave action, without base flood elevation shown.

Zones V1-V30 - special flood hazard area of 100-year coastal flooding with velocity (wave action); base flood elevations shown.

Floodplain

Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually low land adjacent to a river, stream, watercourse, ocean, or lake.

Floodplain Management

The operation of a program of corrective and preventive measures for reducing flood damage, including but not limited to flood control projects, floodplain land-use regulations, flood-proofing of buildings, and emergency preparedness plans.

Floodway

The channel of a river or watercourse and the adjacent land areas that must be reserved to discharge the one-percent-probability flood without cumulatively increasing the water surface elevation more than a designated height, generally one foot.

Hydrology

The science of the behavior of water in the atmosphere, on the earth's surface, and underground.

Hydrodynamic Loads

As flood water flows around a structure it imposes loads on the structure. These loads consist of frontal impact by the mass of moving water against the structure, drag effect along the sides of the structure, and eddies or negative pressure on the structure's downstream side.

Hydrostatic Loads

Those loads or pressures resulting from the static mass of water at any point of flood water contact with a structure. They are equal in all directions and always act perpendicular to the surface on which they are applied. Hydrostatic loads can act vertically on structural members such as floors, decks, and roofs, and can act laterally on upright structural members such as walls, piers, and foundations.

Mean Sea Level

The average height of the sea for all stages of the tide, usually determined from hourly height observations over a nineteen-year period on an open coast or in adjacent waters having free access to the sea.

New Construction

Structures on which construction or substantial improvement was started after the effective date of a community's floodplain management regulations.

One-Hundred Year Flood

(See *Special Flood Hazard Areas).*

Permeability

The property of soil or rock that allows passage of water through it.

Regulatory Floodway

Any floodway referenced in a floodplain ordinance for the purpose of applying floodway regulations.

Special Flood Hazard Areas

Areas in a community that have been identified as susceptible to a one-percent or greater chance of flooding in any given year. A one-percent probability flood is also known as the 100-year flood or the base flood.

Stillwater Elevations

The elevation that the surface of the water would assume if all wave action were absent.

Storm Surge

A rise above normal water level on the open coast due to the action of wind stress and atmospheric pressure on reduction on the water surface.

Substantial Improvement

Any repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure either (a) before the improvement is started or (b) if the structure has been damaged, and is being restored, before the damage occurred.

Watershed

An area from which water drains to a single point; in a natural basin, the watershed is the area contributing flow to a given place or stream.

Wave Height

The vertical distance between a wave crest and the preceding trough.

Wave Crest Elevation

The elevation of the 100-year storm surge plus wave height.

Sources of Design Information

Regulatory Information

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Data
• National Flood Insurance Program (NFIP)	• Requires local communities to implement floodplain regulations. • Sets minimum standards for floodplain regulations. • Prohibits federal funding for projects in violation of floodplain regulations. • Prohibits federal loan guarantees for projects in violation of floodplain regulations. • Establishes flood insurance rate differentials for properties in flood-prone areas.	• Program regulations • Insurance rate information and tables • Flood Insurance Studies • Flood Maps Section 1362 Guidelines	• Federal Insurance Administration • Federal Emergency Management Agency • State Floodplain Management Coordinating Agency • Local Government Planning Agency
• Local Government Planning Programs	• Implements floodplain regulations. • Determines local floodplain regulations based on NFIP guidelines (includes zoning and subdivision regulations, performance standards, Planned Unit Development ordinances, building codes, etc.) Note: Local regulations can be set at a higher standard than NFIP minimum standards, depending on local needs and circumstances.	• Planning and Zoning Ordinances • Zoning Maps • Building Codes	• Local Government Planning Agency • Local Government Engineer • Building Code Officials
• State Floodplain and Coastal Zone Programs	• Provides statewide floodplain development regulations and guidelines. • Regulates development in coastal zones. • Coordinates implementation of NFIP in local jurisdictions and in areas where multiple state agencies have an interest in flooding. • Clearinghouse for Floodplain Management Information.	• State program regulations • State development guidelines	• State Floodplain Management Coordinating Agency • State Office of Coastal Zone Management • State Office of Natural or Water Resources
• Regional Planning Restrictions or Guidelines	• Can provide additional regulations and guidelines for regional jurisdictions. • Coordinates activities of different agencies within the region. • Source of information and, in some cases, technical assistance.	• Program regulations • Development guidelines	• Regional Authorities (e.g., Tennessee Valley Authority, Appalachian Regional Commission, etc.) • Regional Planning Commissions • River Basin Commissions
• Federal Agency Requirements and Guidelines (other than NFIP)	• May include regulations relating to development in flood-prone areas (e.g., Corps of Engineers permits for development on navigable rivers). • May involve federal funding, the use of which is restricted in flood-prone areas. • Projects may require federal approval for development in flood-prone areas (e.g., Environmental Impact Statements).	• Program regulations	• U.S. Army Corps of Engineers • Environmental Protection Agency • Federal Emergency Management Agency • State Floodplain Management Coordinating Agency • Local Planning Agency

Hydrologic Data

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Information
• Flood Hazard Boundaries	• Determines where floodplain regulations, insurance, and federal financing restrictions apply. • Determines specific flood hazard zones. • Determines variable flood insurance rate zones.	• Flood Hazard Boundary Maps • Flood Insurance Rate Maps • Flood Boundary and Floodway Maps • Hydrologic Atlases • Local Zoning Maps • Flood Insurance Studies	• Local Government Planning Agency • Local Government Municipal Engineer • State Floodplain Coordinating Agency • State Office of Natural Resources • Federal Insurance Administration • Federal Emergency Management Agency • U.S. Army Corps of Engineers • U.S. Geologic Survey
• Flood Depths	• Indicates elevations at which flood damage is likely to occur. • Determines appropriate building elevations for meeting floodplain regulations and flood insurance restrictions and rates. • Indicates hydrostatic loads in flood-prone areas.	• Flood Elevations • Water Surface Profiles • Stream and Coast Cross-sections • Flood Insurance Studies	
• Flood Water Velocity	• Determines hydrodynamic loads in flood-prone areas. • Determines debris-impact loads in flood-prone areas. • Indicates potential for erosion and slope deterioration.	• Floodplain Technical Studies • Hydrologic Studies • Flood Insurance Studies	

• Warning Time	• Indicates importance of emergency evacuation as part of the design program. • Influences design of floodproofing techniques such as flood shields. • Influences design of drainage systems. • Influences design of wet floodproofing techniques.	• Hydrographs • Floodplain Technical Studies • Historical Records • Flood Insurance Studies	• Regional Authorities —Tennessee Valley Authority —Appalachian Regional Commission —River Basin Commissions • Hydrologic Engineering Consultants • Surveys by Professional Staff • U.S. Department of the Interior Water and Power Resources Service (operates west of the Mississippi River.)
• Duration of Flooding	• Affects seepage into buildings and saturation of soils and building materials. • Affects the length of time facilities might be inaccessible or inoperable. • Affects building design relative to orientation, configuration, and choice of floodproofing techniques.	• Floodplain Technical Studies • Historical Records • Flood Insurance Studies	
• Frequency of Flooding	• Influences site choice. • Affects choice of floodproofing techniques, especially those that require installation before every flood. • Indicates need for special access.	• Floodplain Technical Studies • Historical Records	
• Climate and Weather	• Indicates frequency and type of precipitation and, in turn, the type and magnitude of flooding that is likely.	• Weather Service Records • Historical Records	
• Ground Water Level	• Influences potential water pressure on footings, foundations, and floors. • Affects site design techniques for controlling water runoff.	• Geologic Surveys • Soil Analysis Reports	
• Structural Flood Control Measures (e.g., dams, levees, channel improvements)	• Existing measures can affect site if the limits of the flood control device are exceeded. • Proposed measures can, when implemented, alter basic flood data.	• Feasibility Studies • Design Specifications • Probability Reports	

Hydrologic Data

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Information
• Physiographic Features	• Affects location and magnitude of flooding on the site. • Identifies areas of the site that should be avoided or protected. • Affects orientation, distribution, and density of built elements on the site. • Identifies physical constraints and advantages for site development.	• Topographic Maps • Floodplain Technical Studies • Site Surveys	• Local Government Planning Agency • Local Government Municipal Engineer • State Floodplain Coordinating Agency • State Office for Natural Resources • Soil Conservation Service, U.S. Department of Agriculture • U.S. Geologic Survey • Regional Authorities • Hydrologic and Civil Engineering Consultants • Surveys by Professional Staff • U.S. Department of the Interior Water and Power Resources Service (operates west of the Mississippi River.)
• Topography	• Influences siting of buildings. • Indicates erosion potential. • Indicates need for, and feasibility of using, fill material on the site. • Indicates appropriate site design techniques for controlling water runoff.	• Topographic Maps • Floodplain Technical Studies • Site Surveys	
• Soil Characteristics	• Soil porosity influences the rate of water runoff and flooding potential. • Determines the feasibility and design specifications for use of fill material to elevate buildings, the use of backfill around foundations, and construction of earth berms. • Indicates required depth for footings, pilings, or columns.	• Soil Maps • Soil Analysis Reports • Site Surveys	
• Slope Stability	• Affects choice of building sites, the use of fill material, and the design of foundations, footings, and pilings. • Influences erosion. • Indicates the need for terracing or ground cover to protect slopes.	• Analysis of combined effects of topography and soil characteristics • Site Surveys	
• Vegetation	• Aids in control of water runoff, and thus can be a factor in reducing flooding levels.	• Site Surveys	
• Water Storage	• Aids in control of water runoff, and thus can be a factor in reducing flooding levels. • Recharges ground water supplies.	• Geologic, soil, and hydrologic surveys • Site Surveys	

Site Characteristics

FEMA Regional Offices

The Federal Emergency Management Agency (FEMA) was created in 1978 to provide a single point of accountability for all federal activities related to disaster mitigation and emergency preparedness and response. It was established as an independent agency in the executive branch to consolidate a variety of existing agencies and offices performing related functions. The Federal Insurance Administration (FIA), formerly a part of the Department of Housing and Urban Development, is only responsible for administering the National Flood Insurance Program. This responsibility includes assisting state and local governments in the implementation of flood-plain management programs and providing information on flooding to communities and individuals. Regional offices are the primary means by which FEMA's programs are carried out at the state and local level.

Region I

Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island & Vermont

J.W. MacCormack Post Office Building, Room 442
Boston, Massachusetts 02109
(617) 223-9540

Region II

New Jersey, New York, Puerto Rico & Virgin Islands

26 Federal Plaza
Rm. 1349
New York, New York 10278
(212) 264-8980

Region III

Delaware, District of Columbia, Maryland, Pennsylvania, Virginia & West Virginia

Liberty Square Building
105 South Seventh Street
Philadelphia, Pennsylvania 19106
(215) 597-9416

Region IV

Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina & Tennessee

1375 Peachtree Street, N.W.
Suite 700
Atlanta, Georgia 31792
(404) 347-2400

Region V

Illinois, Indiana, Michigan, Minnesota, Ohio & Wisconsin

300 South Wacker Drive
24th Floor
Chicago, Illinois 60606
(312) 353-8661

Region VI

Arkansas, Louisiana, New Mexico, Oklahoma & Texas

Federal Regional Center
Rm. 206
800 North Loop 288
Denton, Texas 76201
(817) 387-5811

Region VII

Iowa, Kansas, Missouri & Nebraska

911 Walnut Street
Room 300
Kansas City, Missouri 64106
(816) 374-5912

Region VIII

Colorado, Montana, North Dakota, South Dakota, Utah & Wyoming

Federal Regional Center
Building 710, Box 25267
Denver, Colorado 80225
(303) 235-4811

Region IX

Arizona, California, Hawaii & Nevada

Building 105
Presidio of San Francisco
San Francisco, California
94129
(415) 556-8794

Region X

Alaska, Idaho, Oregon & Washington

Federal Regional Center
130 228th Street, S.W.
Bothell, Washington 98011
(206) 481-8800

Federal Emergency Management Agency
Regional Offices and Boundaries

State Coordinating Offices for the NFIP

Each of the states, in cooperation with the Federal Emergency Management Agency, has designated a specific agency to coordinate implementation of the National Flood Insurance Program. This agency provides a link between federal, state, and local levels of government and between different state agencies with flood-related responsibilities. The designated agency will typically be a department responsible for natural resources, emergency services, or physical development, and is a focal point for information relating to flood insurance and floodplain management. It can be an important source of physical data, information on community eligibility for flood insurance, relevant state regulations, references to other agencies, and, in some instances, technical assistance. The authority of each state's coordinating agency varies, and can best be determined through direct contact.

Alabama

Department of Economics and Community Affairs
State Planning Division
P.O. Box 2939
3465 Norman Bridge Road
Montgomery, Alabama 36105
(205) 284-8735

Alaska

Department of Community & Regional Affairs
Division of Municipal and Regional Affairs
949 East 36 Avenue
Suite 400
Anchorage, Alaska 99508
(907) 561-8586

Arizona

Department of Water Resources
Flood Control Branch
99 E. Virginia 2nd Floor
Phoenix, Arizona 85004
(602) 255-1566

Arkansas

Soil & Water Conservation Commission
#1 Capitol Mall
Suite 2D
Little Rock, Arkansas 72201
(501) 371-1611

California

Department of Water Resources
P.O. Box 388
Sacramento, California 95802
(916) 445-6249

Colorado

Colorado Water Conservation Board
State Centennial Building, Room 823
1313 Sherman Street
Denver, Colorado 80202
(303) 866-3441

Connecticut

Dept. of Environmental Protection
165 Capitol Avenue
Hartford, Connecticut 06106
(203) 566-7245

Delaware

Dept. of Natural & Environmental Control
Division of Soil & Water Conservation
Edward Tatnall Building
P.O. Box 1401
Dover, Delaware 19901
(302) 736-4411

District of Columbia

Department of Consumer Regulatory Affairs
614 H Street, N.W.
Washington, D.C. 20001
(202) 727-7577

Florida

Department of Community Affairs
Div. of Resource Planning and Management
2571 Executive Ctr. Circle East
Tallahassee, Florida 32301
(904) 488-9210

Georgia

Georgia Department of Natural Resources, Environmental Protection Division
19 Martin Luther King, Jr. Dr. , S.W., Room 400
Atlanta, Georgia 30334
(404) 656-3214

Guam

Office of Civil Defense
Post Office Box 2877
Agana, Guam 96910
011—671—477—9841

Hawaii

Hawaii Board of Land and Natural Resources
P.O. Box 373
Honolulu, Hawaii 96809
(808) 548-7539

Idaho

Department of Water Resources
State House
Boise, Idaho 83720
(208) 334-4470

Illinois

Illinois Department of Transportation
Division of Water Resources
Local Flood Plain Programs
300 North State Street, Room 1010
Chicago, Illinois 60610
(312) 793-3864

Indiana

Department of Natural Resources
608 State Office Building
Indianapolis, Indiana 46204
(317) 232-4160

Iowa

Iowa Natural Resources Council
Wallace State Office Building
Des Moines, Iowa 50319
(515) 281-5029

Kansas

Kansas State Board of Agriculture
Division of Water Resources
109 Southwest Ninth Street
Topeka, Kansas 66612
(913) 296-3717

Kentucky

Department of Natural Resources
Division of Water
18 Reilly Road
Fort Boone Plaza
Frankfort, Kentucky 40601
(502) 564-3410

Louisiana

Louisiana Department of Urban & Community Affairs
P.O. Box 44455, Capitol Station
Baton Rouge, Louisiana 70804
(504) 925-3730

Maine

Bureau of Civil Emergency Preparedness
State House
187 State Street
Augusta, Maine 04330
(207) 289-3154

Maryland

Maryland Water Resources Administration
Flood Management Section
Tawes State Office Building D-2
Annapolis, Maryland 21401
(301) 269-3826

Massachusetts

Massachusetts Water Resources Commission
State Office Building
100 Cambridge Street
Boston, Massachusetts 02202
(617) 727-3267

Michigan

Michigan Department of Natural Resources
Water Management Division
P.O. Box 30028
Lansing, Michigan 48909
(517) 373-3930

Minnesota

Minnesota Department of Natural Resources
Division of Waters
444 LaFayette Road
St. Paul Minnesota 55101
(612) 296-9226

Mississippi

Mississippi Research & Development Center
3825 Ridgewood Road
Jackson, Mississippi 39211
(601) 982-6376

Missouri

Department of Natural Resources
1101 R. Southwest Blvd.
P.O. Box 1368
Jefferson City, Missouri 65102
(314) 751-4932

Montana

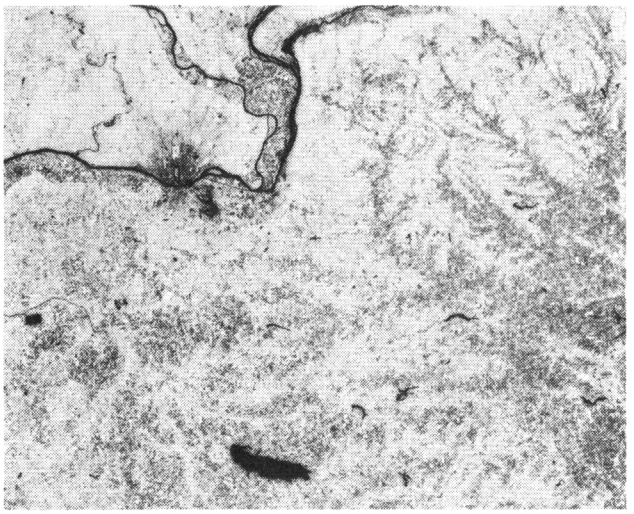
Department of Natural Resources & Conservation
32 South Ewing Street
Helena, Montana 59601
(406) 449-6646

Nebraska

Nebraska Natural Resources Commission
P.O. Box 94876
Lincoln, Nebraska 68509
(402) 471-2081

Nevada

Division of Emergency Management
Capitol Complex
Carson City, Nevada 89710
(702) 885-4240



New Hampshire

New Hampshire Office of State Planning
2½ Beacon Street
Concord, NH 03301
(603) 271-2231

New Jersey

New Jersey Department of Environmental Protection
Division of Water Resources
P.O. Box CN 029
Trenton, New Jersey 08625
(609) 292-2296

New Mexico

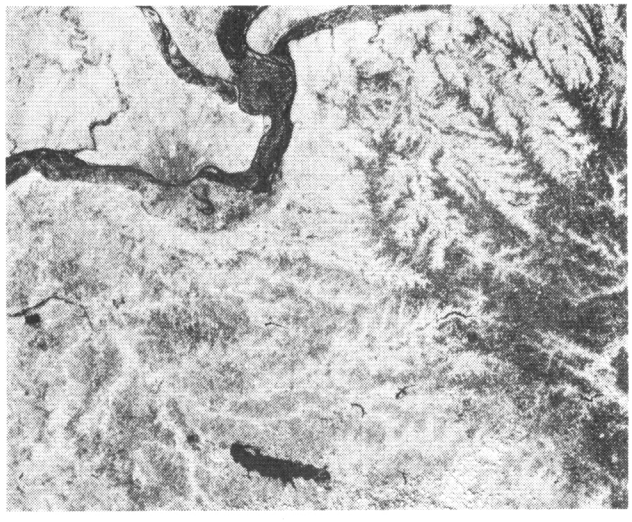
State Engineer
Bataan Memorial Bldg.
Santa Fe, New Mexico 97501
(505) 827-6140

New York

New York Department of Environmental Conservation
Flood Protection Bureau
50 Wolf Road-Room 422
Albany, New York 12233
(518) 457-3157

North Carolina

North Carolina Department of Natural Resources & Community Development
Division of Community Assistance
512 North Salisbury Street
P.O. Box 27687
Raleigh, North Carolina 27611
(919) 733-2850



North Dakota
State Water Commission
900 E. Boulevard
Bismarck, North Dakota
58501
(701) 224-2750

Ohio
Ohio Department of Natural
Resources
Flood Plain Planning Unit
Fountain Square
Columbus, Ohio 43224
(614) 265-6755

Oklahoma
Oklahoma Water Resources
Board
12th Floor Northeast
10th & Stonewall
Oklahoma City, OK 73105
(405) 271-2533

Oregon
Department of Land
Conservation and
Development
1175 Court Street, N.E.
Salem, Oregon 97310
(503) 378-2332

Pennsylvania
Department of Community
Affairs
551 Forum Building,
Room 317
Harrisburg, PA 17120
(717) 787-7400

Puerto Rico
Puerto Rico Planning Board
P.O. Box 4119, Minillas
Station
D-Diego Avenue
Santurce, Puerto Rico 00940
(809) 726-7110

Rhode Island
Rhode Island Office of State
Planning
Statewide Planning Program
265 Melrose Street
Providence, RI 02907
(401) 277-2656

South Carolina
South Carolina Water
Resources Commission
3830 Forest Drive
P.O. Box 4440
Columbia, SC 29240
(803) 758-2514

South Dakota
Department of Military and
Veterans Affairs
Division of Emergency and
Disaster
State Capitol
Pierre, South Dakota 57501
(605) 773-3231

Tennessee
Department of Economic
and Community
Development
Division of Local Planning
1800 James K. Polk
Office Building
505 Deaderick Street
Nashville, Tennessee 37219
(615) 741-2211

Texas
Texas Dept. of Water
Resources
P.O. Box 13087, Capitol
Station
1700 North Congress
Avenue
Austin, Texas 78711
(512) 475-2171

Utah
Office of Comprehensive
Emergency Management
1543 Sunnyside Avenue
Salt Lake City, Utah 84108
(801) 533-5271

Vermont

Environmental Conservation Agency
Division of Water Resources
State Office Building
Montpelier, Vermont 05602
(802) 828-2761

Virgin Islands

Disaster Preparedness Office
Box 1208
St. Thomas, VI 00801
(809) 774-6555

Virginia

Virginia State Water Control Board
P.O. Box 11143
Richmond, Virginia 23230
(804) 257-0075

Washington

Department of Ecology
Mail Stop PV11
Olympia, Washington 98504
(206) 459-6288

West Virginia

West Virginia Office of Emergency Services
Room EB-80
Capitol Building
Charleston, WV 25305
(304) 348-3831

Wisconsin

Department of Natural Resources
Flood Plain-Shoreline Management Section
P.O. Box 7921
Madison, Wisconsin 53707
(608) 266-1926

Wyoming

Wyoming Disaster and Civil Defense Agency
P.O. Box 1709
Cheyenne, Wyoming 82003
(307) 777-7566

Performance Criteria

The following performance requirements and criteria identify a range of considerations that should be addressed during the design of residential structures for flood hazard areas. These performance criteria do not represent the entire range of items applicable to each requirement. Instead, a selective number of criteria have been presented.

The performance requirements and criteria are applicable to all structural materials and all construction methods used in flood hazard areas. Traditional or conventional construction solutions, as well as innovative techniques, are acceptable so long as the performance requirements and criteria are satisfied.

DEFINITIONS

Terms important to proper interpretation of the performance requirements and criteria are defined as follows:

Applicable Codes

The system of legal regulations adopted by a community setting forth standards for the construction, addition, modification, and repair of buildings and other structures for the purpose of protecting the health, safety and general welfare of the public.

Community

Any state or political subdivision thereof with authority to adopt and enforce floodplain management regulations for areas within its jurisdiction.

Design Flood (Base Flood)

The design flood is the base or 100-year flood used for purposes of compliance with the National Flood Insurance Program (NFIP).

In coastal high hazard zones the 100-year flood includes wave height above the stillwater level.

Design Loads

The design load is the minimum loading condition that the building should be designed to resist. Some loading conditions most likely will be defined in the applicable codes while other load conditions (e.g., flood impact loads) will have to be determined. The following loads constitute the design load and should be considered as minimum loading conditions as defined in Criterion A.1 (see below):

Dead Load (D)

The weight of all permanent construction. The dead load includes a) the weight of the structure itself, b) the weight of all materials of construction incorporated into the building that are to be permanently supported by the structure, including built-in partitions, c) the weight of permanent equipment, and d) forces due to prestressing.

Gravity Live Load (L)

Gravity live loads result from both the occupancy (floor) and the environment (roof) of the building, as stipulated in the applicable code. These include, where applicable, loads caused by soil and hydrostatic pressures.

Wind Loads (W)

Wind loads stipulated in the applicable code.

Restraint Loads (R)

Loads, forces, and effects due to contraction or expansion resulting from temperature changes, shrinkage, moisture changes, creep in component materials, movement due to differential settlement or combinations thereof.

Flood Loads (F)

Loads caused by the design flood, which include:

- Flood-induced dimensional changes such as swelling of wood or heave of expansive foundation soils
- Water loads as defined in Section 602.0 of the Corps of Engineers' publication, *Flood-Proofing Regulations*
- Soil loads as defined in Section 604.0 of the Corps of Engineers' publication, *Flood-Proofing Regulations*

Sections of 602.0 and 604.0 of *Flood-Proofing Regulations* (EP 116S-2-314, Office of the Chief of Engineers, U.S. Army, June 1972), are reproduced below:

SECTION 602.0 WATER LOADS

Sec. 602.1 Types

Water loads, as defined herein, are loads or pressures on surfaces of the buildings and structures caused and induced by the presence of flood waters. These loads are of two basic types: hydrostatic and hydrodynamic.

Sec. 602.2 Hydrostatic Loads

Hydrostatic loads are those caused by water either above or below the ground surface, free or confined, which is either stagnant or moves at very low velocities, or up to five (5) feet per second. These loads are equal to the product of the water pressure times the surface area on which the pressure acts. The pressure at any point is equal to the product of the unit weight of water (62.5 pounds per cubic foot) multiplied by the height of water above the point or by the height to which confined water would rise if free to do so. Hydrostatic pressures at any point are equal in all directions and always act perpendicular to the surface on which they are applied. For the purpose of these Regulations, hydrostatic loads are subdivided into the following types:

Sec. 602.2.1 Vertical Loads

These are loads acting vertically downward on horizontal or inclined surfaces of buildings or structures, such as roofs, decks or floors, and walls, caused by the weight of flood waters above them.

Sec. 602.2.2 Lateral Loads

Lateral hydrostatic loads are those which act in a horizontal direction, against vertical or inclined surfaces, both above and below the ground surface and tend to cause lateral displacement and overturning of the building, structure, or parts thereof.

Sec. 602.2.3 Uplift

Uplift loads are those which act in a vertically upward direction on the underside of horizontal or sloping surfaces of buildings or structures, such as basement slabs, footings, floors, decks, roofs and overhangs. Hydrostatic loads acting on inclined, rounded or irregular surfaces may be resolved into vertical or uplift loads and lateral loads based on the geometry of the surfaces and the distribution of hydrostatic pressures.

Sec. 602.3 Hydrodynamic Loads

Hydrodynamic loads . . . are those induced on buildings or structures by the flow of flood water moving at moderate or high velocity around the buildings or structures or parts thereof, above ground level. Such loads may occur below the ground level when openings or conduits exist which allow free flow of flood waters. Hydrodynamic loads are basically of the lateral type and relate to direct impact loads by the moving mass of water, and to drag forces as the water flows around the obstruction. Where application of hydrodynamic loads is required, the loads shall be computed or estimated by recognized and authoritative methods. Methods for evaluating water velocities and related dynamic effects are beyond the scope of these Regulations, but shall be subject to review and approval by the Building Official.

Sec. 602.3.1 Conversion to Equivalent Hydrostatic Loads

For cases when water velocities do not exceed 10 feet per second, dynamic effects of the moving water may be converted into equivalent hydrostatic loads by increasing the depth of water to the RFD [use the level of the base or design flood], by an amount dh, on the headwater side and above the ground level only, equal to:

$$dh = \frac{aV^2}{2g}, \text{ where}$$

V is the average velocity of the water in feet per second;
g is the acceleration of gravity, 32.2 feet per second;
a is the coefficient of drag or shape factor (The value of a, unless otherwise evaluated, shall not be less than 1.25)

The equivalent surcharge depth, dh, shall be added to the depth measured between the design level and the RFD and the resultant pressures applied to, and uniformly distributed across, the vertical projected area of the building or structure which is perpendicular to the flow. Surfaces parallel to the flow or surfaces wetted by the tailwater shall be considered subject to hydrostatic pressures for depths to the RFD only.

Sec. 602.4 Intensity of Loads

Sec 602.4.1 Vertical Loads

Full intensity of hydrostatic pressure caused by a depth of water between the design elevation(s) and the RFD applied over all surfaces involved, both above and below ground.

Sec. 602.4.2 Lateral Loads

Full intensity of hydrostatic pressure caused by a depth of water between the design elevation(s) and the RFD applied over all surfaces involved, both above and below ground level, except that for surfaces exposed to free water, the design depth shall be increased by one foot.

Sec. 602.4.3 Uplift

Full intensity of hydrostatic pressures caused by a depth of water between the design level and the RFD acting on all surfaces involved . . . .

Sec. 602.4.4 Hydrodynamic Loads

Hydrodynamic loads, regardless of method of evaluation, shall be applied at full intensity over all above ground surfaces between the ground level and the RFD.

Sec. 602.5 Applicability

Hydrostatic loads shall be used in the design of buildings and structures exposed to water loads from stagnant flood waters, for conditions when water velocities do not exceed five (5) feet per second, and for buildings and structures or parts thereof not exposed or subject to flowing water. For buildings and structures, or parts thereof, which are exposed and subject to flowing water having velocities greater than five (5) feet per second, hydrostatic and hydrodynamic loads shall apply.

SECTION 604.0 SOIL LOADS

Sec. 604.1 Applicability

Full consideration shall be given in the design of buildings, structures and parts thereof, to the loads or pressures resulting from the presence of soils against or over the structure. Loads or pressures shall be computed in accordance with accepted engineering practice, giving full consideration to the effects that the presence of flood water, above or within the soil, has on loads and pressures. When expansive soils are present, the Building Official may require that special provisions be made in foundation and wall design and construction to safeguard against damage due to this expansiveness. He may require a special investigation and report to provide these design and construction criteria.

Flood Impact Loads (Fl)

The loads caused by the design flood as defined in Section 603.0, "Impact Loads," and Section 605.0, "Hurricane and Tidal Wave Loads," of the Corps of Engineers' publication, *Flood-Proofing Regulations*. In the case of Section 605.0, where no specific guidance is provided, design loads shall be recommended by a professional engineer. (Also refer to FIA-7, *Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas*, cited in this manual's preface.)

Section 603.0 of *Flood-Proofing Regulations* is reproduced below:

SECTION 603.0 IMPACT LOADS

Sec. 603.1 Types

Impact loads are those which result from floating debris, ice and any floatable object or mass carried by flood waters striking against buildings and structures or parts thereof. These loads are of three basic types: normal, special and extreme.

Sec. 603.1.1 Normal Impact Loads

Normal impact loads are those which relate to isolated occurrences of logs, ice blocks or floatable objects of normally encountered sizes striking buildings or parts thereof.

Sec. 603.1.2 Special Impact Loads

Special impact loads are those which relate to large conglomerates of floatable objects, such as broken up ice floats and accumulation of floating debris, either striking or resting against a building, structure, or parts thereof.

Sec. 603.1.3 Extreme Impact Loads

Extreme impact loads are those which relate to large floatable objects and masses such as runaway barges or collapsed buildings and structures, striking the building, structure or component under consideration.

Sec. 603.2 Applicability

Impact loads should be considered in the design of buildings, structures and parts thereof as stipulated below:

Sec. 603.2.1 Normal Impact Loads

A concentrated load acting horizontally at the RFD or at any point below it, equal to the impact force, produced by a 1,000-pound mass traveling at the velocity of the flood water and acting on a one (1) square foot surface of the structure.

Sec. 603.2.2 Special Impact Loads

Where special impact loads are likely to occur, such loads shall be considered in the design of buildings, structures, or parts thereof. Unless a rational and detailed analysis is made and submitted for approval by the Building Official, the intensity of load shall be taken as 100 pounds per foot acting horizontally over a one-foot wide horizontal strip at the RFD [use the level of the base or design flood], or at any level below it. Where natural or artificial barriers exist which would effectively prevent these special impact loads from occurring, the loads may be ignored in the design.

Sec. 603.2.3 Extreme Impact Loads

It is considered impractical to design buildings having adequate strength for resisting extreme impact loads. Accordingly, except for special cases when exposure to these loads is highly probable and the resulting damages are extremely severe, no allowances for these loads need be made in the design.

Flood or Flooding

– A general and temporary condition of partial or complete inundation of normally dry land areas from:

- the overflow of inland or tidal waters
- the unusual and rapid accumulation or run-off of surface waters from any source
- mudslides (i.e., mudflows) which are proximately caused or precipitated by accumulations of water on or under the ground.

- The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as a flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined above.

PERFORMANCE REQUIREMENTS AND CRITERIA FOR RESIDENTIAL STRUCTURES IN FLOOD HAZARD AREAS

PERFORMANCE REQUIREMENT A

The building, its contiguous structure(s), and its service systems shall be designed to withstand the design flood without causing unacceptable risks to its occupants or to adjacent property owners.

The building complies with Performance Requirement A if the following conditions are satisfied:

Criterion A.1: Strength

The building is designed to resist the following loads, acting simultaneously:

1.1 D, L, R, and F
1.2 D, L, R, F, and Fl
1.3 D, L, R, W, F, and Fl
1.4 D, R, and F
1.5 D, R, W, F, and Fl

Where the working stress method of design is used the following provisions apply:

2.1 In load combinations 1.1 through 1.5 all loads are applied as listed or as required by the applicable codes for the same load combinations with loads F and Fl.

2.2 Allowable (working) stresses cannot be exceeded for loading conditions 1.1 and 1.4. For all other loading conditions the allowable stresses can be increased by the amount permitted in applicable codes for design against load combinations including wind or earthquake load.

Where ultimate-load design is used (such as instances where the American Concrete Institute, *Building Code Requirements for Reinforced Concrete* [AC1 378, ACI, Detroit, current edition], is applicable) load factors are applied as recommended in the applicable standard, and F will be combined with L, or factored as if it were a live load for loading conditions 1.1 and 1.4. For all other loading conditions loads F + Fl will be combined with W, or considered to be equivalent to a wind load.

Test

Structural analysis and/or physical simulation.

Commentary

The criterion provides a suitable margin of safety against structural collapse when the building is subjected to the base flood. The intent of the criterion is that the margin of safety for these buildings, when subjected to the base flood, be no less than the margin required for other buildings not subjected to flooding. It is assumed that loads F may act on the building over a long period of time, while loads Fl are short-term loads. Thus the margin of safety against load combinations containing Fl need not exceed that provided against wind or seismic loads.

The combined load of earthquakes and floods is not considered here because of the low probability of a flood and an earthquake occurring simultaneously. Where tsunami flooding is the base flood, earthquake loading should perhaps be considered concurrently.

Criterion A.2: Stability and Flotation

There shall be a factor of safety of 1.5 against overturning, sliding, and flotation under the following load:

D + W + R + F + Fl

Test

Structural analysis and/or physical simulation.

Commentary

This criterion provides a suitable margin of safety against sliding and overturning. The most critical load combination is being considered. Tie-down devices can be used to achieve structural stability, provided it can be demonstrated that deterioration of these devices during the service life of the building or by flood conditions will not cause the factor of safety to fall below its stipulated value.

Criterior A.3: Provision Against Debris and Scour

Unless it can be demonstrated that the flood waters will be stagnant, or that there will be no floating debris during the design flood, the following provisions apply:

1.1 Building on stilts shall comply with Section 612.2.3 of the Corps of Engineers' publication, *Flood-Proofing Regulations*. This section is reproduced below.

Sec. 612.2.3 Building on "Stilts"

The building may be constructed above the RFD [use the level of the base or design flood] by supporting it on "stilts" or other columnar type members, such as columns, piers, and in certain cases, walls. Clear spacing of support members, measured perpendicular to the general direction of flood flow shall not be less than eight (8) feet apart at the closest point. The "stilts" shall, as far as practicable, be compact and free from unnecessary appendages which would tend to trap or restrict free passage of debris during a flood. Solid walls, or walled in columns are permissible if oriented with the longest dimension of the member parallel to the flow. "Stilts" shall be of a type that causes the least obstruction to the flow and the least potential for trapping floating debris. Foundation supports for the "stilts" may be of any approved type capable of resisting all applied loads, such as spread footings, mats, piles and similar types. In all cases, the effect of submergence of the soil and additional flood water related loads shall be recognized. The potential of surface scour around the stilts shall be recognized and protective measures provided, as required.

1.2 For flow velocities in excess of 5 feet per second the hydrodynamic loads in F shall be assumed to act over the entire width of the building, perpendicular to the direction of flow, and reasonable vertical clearance shall be provided for the passage of debris. The depth of all foundation elements shall allow for the potential effect of scour.

Test

Structural analysis and/or physical simulation. Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Commentary

Criterion A.3 is designed to prevent structural collapse caused by the accumulation of floating debris or the undermining of foundation elements as a result of scour. Part of the provision is designed to avoid debris accumulation. The other part provides adequate strength to resist the effects of the formation of a barrier over the entire width of the building. Buildings are exempt if it can be demonstrated that no debris will accumulate and no scour will occur.

Criterion A.4: Disruption of Service Systems

The service systems shall be designed to resist the loads stipulated in Criterion A.1 with safety margins as stipulated in A.1 against disruptions which may endanger human lives.

Test

Engineering analysis and/or physical simulation. Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Commentary

This criterion only applies to disruption which may cause fatal accidents, such as rupture of gas lines. Lesser load levels are stipulated in B.1 for disruptions which constitute a health hazard.

Criterion A.5: Execution of Rescue Operations

The building is designed to permit the execution of rescue operations.

During the duration and at heights of the design flood the building shall:

1.1 Allow the safe evacuation of the occupants out of the building
1.2 Allow the safe transfer of occupants from the building to rescue vehicles
1.3 Provide means of access or adjacency for rescue vehicles.

Test

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Commentary

Criterior A.5 is designed to prevent the entrapment of building occupants by rising water levels. Part of the provision is designed to provide means to evacuate the building (e.g., windows, roof trap door). The other parts provide for the accomodation and execution of rescue operations (e.g., by boat, helicopter).

PERFORMANCE REQUIREMENT B

The building, its contiguous structure(s), and its service systems shall be designed to withstand the design flood without causing unacceptable health hazards to its occupants.

The building complies with Performance Requirement B if the following conditions are satisfied:

Criterion B.1: Disruption of Utility Connections

Building utility connections shall be designed to resist the following loads:

At loading conditions:

1.1 D + L + R + W + F + Fl
1.2 D + W + R + F + Fl

The building utility connections should not sustain:

2.1 Permanently disrupted and/or broken attachment with their fixtures and/or supporting structural elements

2.2 Leakage or escape of effluent that could contaminate drinking water

2.3 Rupture of electrical service that could cause electrocution and/or fire.

Test

Evaluation of data and documentation for design, tests, and installations; evaluation of plans and specifications. Inspection and/or testing of built elements when deemed essential. Determination of conformances to generally accepted codes, standards and engineering and trade practices, where applicable.

Commentary

This criterion applies to all utility connections subject to the forces of the design flood. Utility connections which are designed to disconnect during the design flood without the release of deleterious substances are exempt from provisions 1.1 and 1.2.

Criterion B.2: Provision Against Drinking Water Contamination

There will be no contamination of drinking water with sewer effluent or flood water.

Criterion B.2 and Performance Requirement B are deemed satisfied if the following provisions are met.

1.1 Approved backflow preventers or devices are installed on main water service lines, at water wells and/or at suitable building locations to protect the system from backflow or back siphonage of flood waters or other contaminants in the event of a line break or temporary disconnection.

Devices are installed at accessible locations and maintained in good working order.

1.2 Sanitary sewer and storm drainage system connections are provided with approved backflow preventers or devices installed at each discharge point.

1.3 No storm or flood waters are drained into systems designed for sewage only, and vice versa.

Test

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Commentary

Criterion B.2 is designed to prevent contamination of drinking water with sewer effluent or flood waters. Also, the criterion is designed to prevent damage to fixtures and interior finishes (e.g., flooring, wall surfaces) from backflow or back siphonage of flood waters.

Criterion B.3: Provision Against Contamination of Potable Water Wells

Private potable water wells shall not be contaminated by toxic substances or impurities caused by the design flood.

Criterion B.3 is deemed satisfied if the following provisions are satisfied.

1.1 Private potable well water is not supplied from a water table located less than 25 feet below grade, nor from any deeper supply which may be polluted by contamination entering fissure or crevice formations.

1.2 Each well is provided with a watertight casing to a distance of at least 25 feet below the ground surface that extends at least one foot above the well platform.

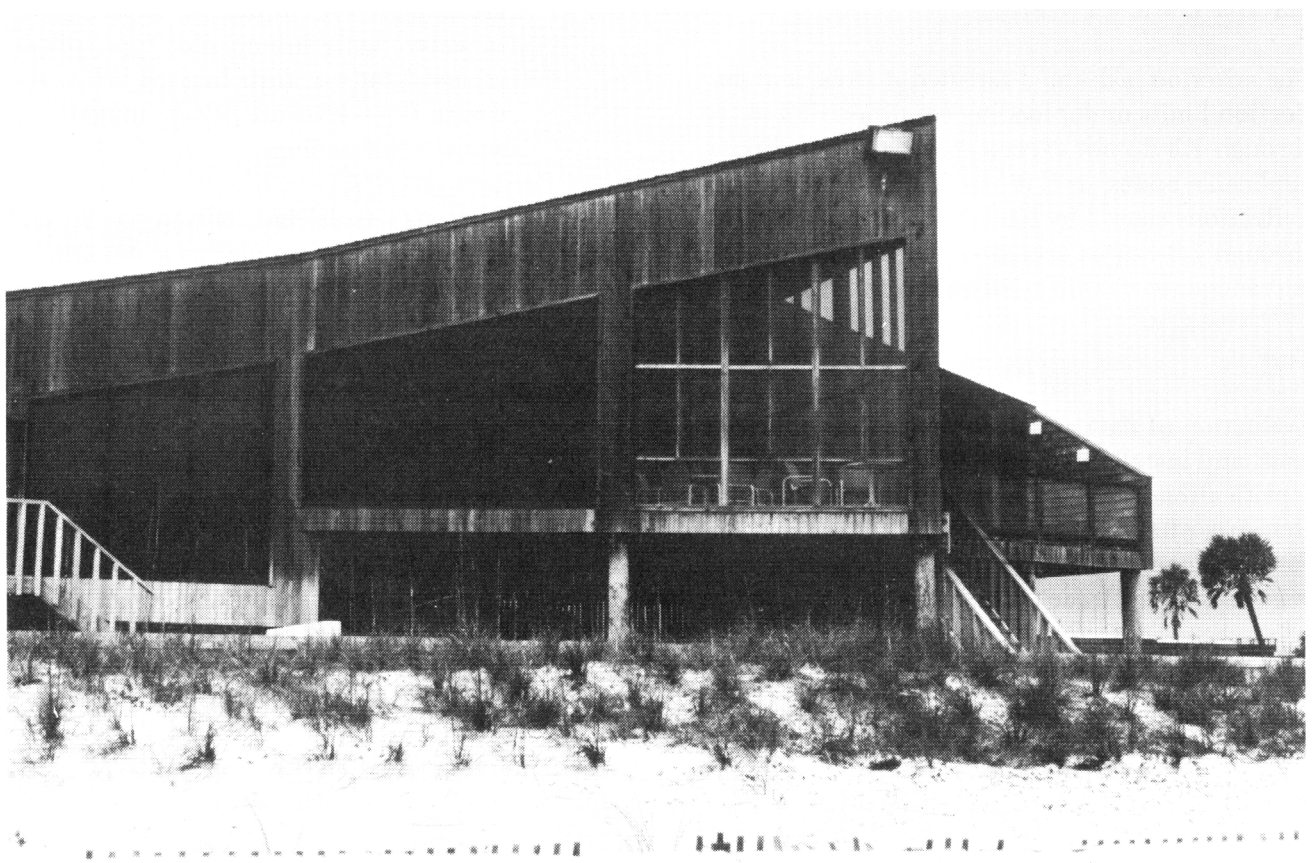
Test

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Geological analysis of site.

Commentary

Criterion B.3 is designed to prevent the contamination of water wells used as a source for potable water. Part of the provision provides against the contamination of the water supply source. The other part provides against the contamination of the water removal system. In any case, local health codes should be consulted.



PERFORMANCE REQUIREMENT C

The building, its contiguous structure(s), and its service systems shall be designed to withstand the design flood without sustaining damage of unacceptable magnitude.

The building complies with Performance Requirement C if the following conditions are satisfied:

Criterion C.1: Provision Against Permanent Damage

Under loading conditions 1.1 through 1.3 the building as a whole, or any element thereof, shall not suffer permanent damage which would require replacement or major repair, or which would extensively impair its intended function.

1.1 D + L + R + W + F + Fl
1.2 D + W + R + F + Fl
1.3 D + L + R + F + Fl

The criterion is deemed satisfied if stress and deflection limits under loading conditions 1.1 through 1.3 do not exceed those stipulated in applicable codes, or if it can be demonstrated that deflections caused by load combinations 1.1 through 1.3 can be accomodated by suitable detail and adequate flexibility of elements.

Test

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications. Inspection and/or testing of built elements when deemed essential. Determination of conformance to generally accepted standards and engineering and trade practices, where applicable.

Commentary

This criterion assures that the design flood will not cause excessive damage. Effects of swelling caused by increased moisture or inundation must be included in F.

Criterion C.2: Provision Against Unnecessary Damage

All living areas, major utilities, furnaces, and air-conditioning units shall not be submerged by the design flood.

1.1 Living areas shall be considered habitable areas that provide for the essential needs of people: living, sleeping, dining, cooking and sanitation.

Recreation areas, libraries, and other speciality areas are to be considered habitable areas and therefore should not be submerged by the design flood.

1.2 The electrical system complies with Criterion C.2 if the following conditions are satisfied:

1.2.1 All portions of the electrical system installed below the design flood level are suitable for continuous submergence in water. Only submersible type splices are used and conduits located below the design flood level are self draining if subject to flooding.

1.2.2 Lighting panels, distribution panels, and all other stationary electrical equipment are located above the design flood.

1.3 The mechanical system complies with Criterion C.2 if the following conditions are satisfied:

1.3.1 Heating, air-conditioning, and ventilating are installed above the design flood.

1.3.2 All duct work for warm air heating systems located below the design flood level is provided with emergency openings for drainage of ducts after a flood condition.

1.4 The plumbing system complies with Criterion C.2 if the following conditions are satisfied:

1.4.1 Tanks, softeners and heaters are installed above the design flood.

1.4.2 Plumbing below the design flood level will not suffer loss of stability or loss of tightness that will permit leakage or physical damage to fixtures and joints and connections that will permanently impair functioning.

1.4.3 Utility connections designed to disconnect during the design flood are easily reconnected. (See Criterion B.1.)

Test

Evaluation of data and documentation for design, tests, and installation; evaluation of plans and specifications.

Commentary

Criterion C.2 is designed to prevent unncessary damage of living areas, major utilities, furnaces, and air-conditioning units by the design flood. Part of the provision is designed to elevate living areas and equipment above the design flood. Other parts are designed to prevent the damage of utilities and mechanical/electrical connections below the design flood.

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